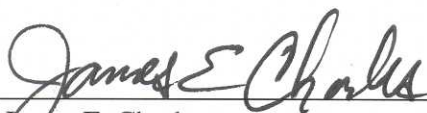


## CRITERION 506

## EMERGENCY AND STANDBY POWER SYSTEMS

## SIGNATURES

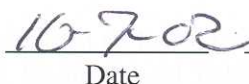
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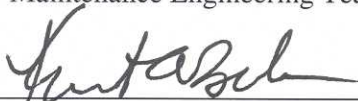
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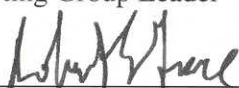
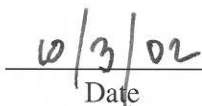
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**RECORD OF REVISIONS**

<b>Revision No.</b>	<b>Date</b>	<b>Description</b>
0	08/27/98	Initial Issue.
1	01/03/02	<p>This revision reflects the conversion from a WordPerfect document into a Microsoft Word document and additional clarification of how to develop criteria. Major revisions to this document includes:</p> <ul style="list-style-type: none"><li>• Incorporates a review of ORPS &amp; NRC lessons learned from 1/1/96 to 9/1/2001</li><li>• The addition of a Table of Contents</li><li>• The use of Basis Statements in Sections 6, 7, and 9</li><li>• Revision to Section 9, "Required Documents,"</li><li>• Further clarification in the use of references.</li></ul>
	10/02/02	<p>Incorporation of formatting and text in 101 Writer's Guide Rev. 3. Renumbered Tables and moved Table 1 to Section 8.2.7</p>

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## **CRITERION 506**

### **EMERGENCY AND STANDBY POWER SYSTEMS**

#### **1.0 PURPOSE**

The purpose of this Criterion is to establish the minimum requirements and best practices for operation and maintenance of engine-driven emergency and standby electrical power generating systems at LANL.

The operation and maintenance of Emergency and Standby Power Systems (E&SPS) will ensure that power is available for life safety, critical, or safety class loads used to protect health and safety of the public, workers, and the environment. It can also reduce the consequences of postulated events involving nuclear, chemical, or other hazards or having adverse impact on the LANL mission.

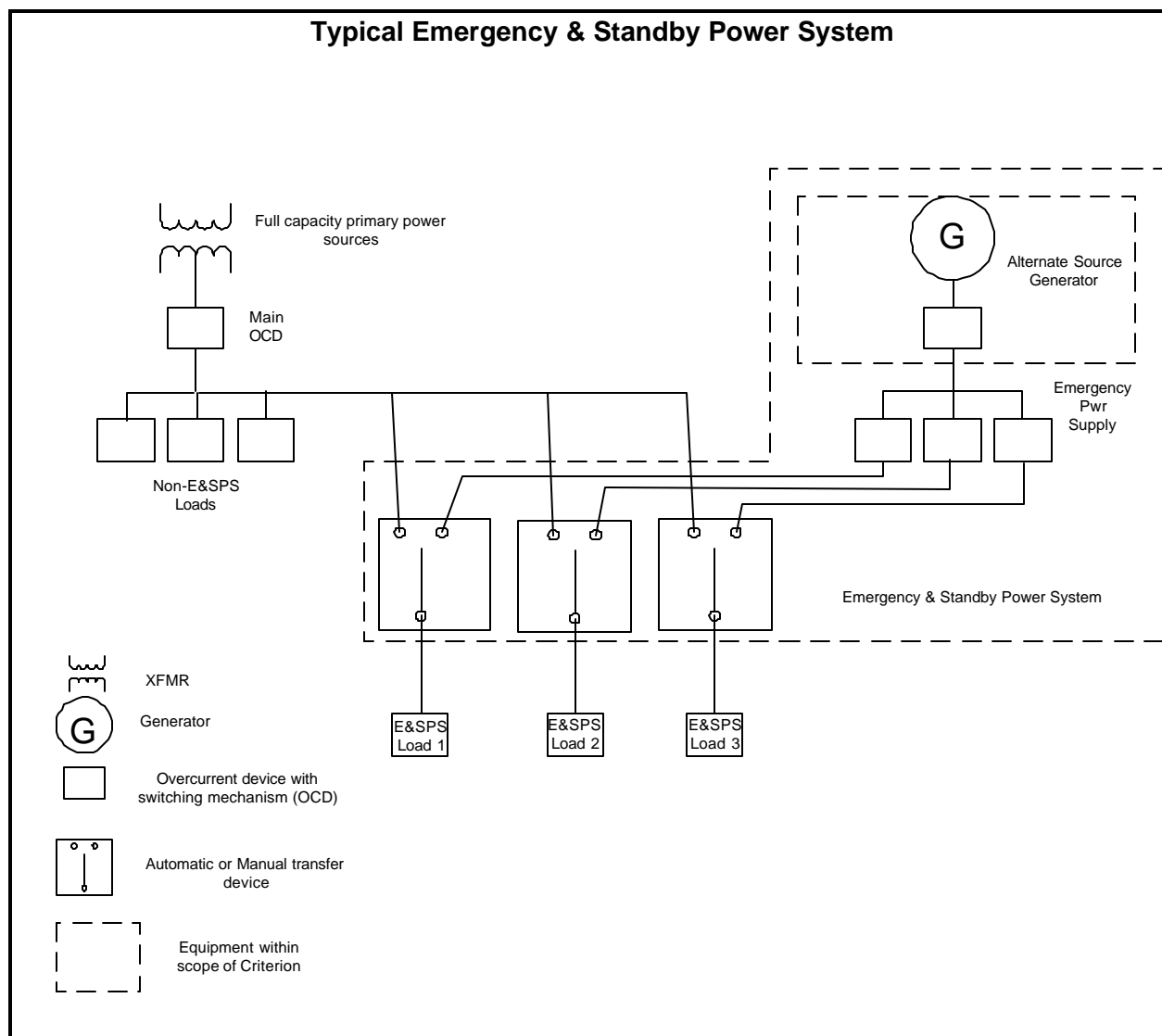
This document addresses the requirements of LIR 230-05-01(Ref 10.1), "Operations and Maintenance Manual."

Implementation of this Criterion satisfies DOE Order 430.1A (Ref 10.2) for the subject equipment / system. DOE Order 430.1A (Ref 10.2) "Life Cycle Asset Management," Attachment 2 "Contractor Requirements Document," Paragraph 2, Sections A through C, which in part requires UC to "...maintain physical assets in a condition suitable for their intended purpose," and employ "preventive, predictive, and corrective maintenance to ensure physical asset availability for planned use and/or proper disposition." Compliance with DOE Order 430.1A is required by Appendix G of the UC Contract.

#### **2.0 SCOPE**

The scope of this Criterion includes the routine inspection, testing, and maintenance of all stationary engine-driven emergency and standby electrical power generating systems. This Criterion does not address corrective maintenance actions required to repair or replace equipment. Systems covered within this document include the driver (the engine), transfer switches, controls, supervisory equipment, generator, related electrical and mechanical auxiliary equipment, and accessory equipment needed to supply electrical power to the load terminals of the transfer switch. Equipment that is **not** included within the scope of this document are storage batteries, electrical battery

chargers, and circuit breakers that may be utilized in electrical power generating systems. This equipment is covered within O&M Criterion 511 "Stationary System Batteries" and O&M Criterion 504 "Low Voltage Electrical Equipment". Additional equipment that is **not** within the scope of this document is uninterruptible power supplies (UPS) that may be interconnected to an engine-driven power generating system, as well as a transfer switch system internal to the UPS. This equipment is covered within O&M Criterion 505 "Uninterruptible Power Supply Systems".



**Figure 2-1** Typical Emergency and Standby Power System

### 3.0 ACRONYMS AND DEFINITIONS

#### 3.1 Acronyms

AHJ	Authority Having Jurisdiction
CFR	Code of Federal Regulations
E&SPS	Emergency & Standby Power Systems
LIG	Laboratory Implementing Guidance
LIR	Laboratory Implementing Requirement
LPR	Laboratory Performance Requirement
ML	Management Level
NFPA	National Fire Protection Association
O&M	Operations and Maintenance
PPE	Personal Protective Equipment
PP&PE	Personal Property and Programmatic Equipment
RP&IE	Real Property and Installed Equipment
SSC	Structures, Systems, and Components
UC	University of California

#### 3.2 Definitions

**Automatic Transfer Switch.** Self-acting equipment for transferring one or more load conductor connections from one power source to another. (IEEE Std 446 Chapter 2 definitions [Ref. 10.11].)

**Cold Start.** Cold starting means low temperature intake air that is coming inside the engine cylinder, low temperature cylinder walls, and low temperature piston head. All these are making fuel evaporation difficult. The usual way to start a diesel engine is to initially flood the engine with fuel. The engine then accelerates to a speed over the idling speed, then the governor kicks in, cutting the fuel, the engine decelerates, fuel is injected again and the cycle repeats itself until a stable speed is reached. This cycle produces the exhaust of water vapors, oil particulate, even some fuel droplets remaining from the previous cycle.

**Emergency and Standby Power System.** An independent reserve source of electric energy that upon failure or outage of the normal source, automatically provides reliable electric power within a specified time to critical devices and equipment whose failure to operate satisfactorily would jeopardize the health and safety of personnel or result in damage to property. (IEEE Std 446 Chapter 2 definitions [Ref. 10.11].)

**Class.** Class defines the minimum time, in hours, for which the E&SPS is designed to operate at its rated load without being refueled. *See Table.* (NFPA 110 "Standard for Emergency and Standby Power Systems" Chapter 2 definitions [Ref. 10.6].)

**Table 3-1 Classification of E&SPS**

<b>Class</b>	<b>Time</b>
Class 0.083	0.083 hours (5 minutes)
Class 0.25	0.25 hours (15 minutes)
Class 2	2 hours
Class 6	6 hours
Class 48	48 hours
Class X	Other time, in hours, as required by the application, code, or user.

**Level.** It is recognized that E&SPS are utilized in many different locations and for many different purposes. The requirement for one application might not be appropriate for other applications. Therefore, the NFPA 110 recognizes two levels of equipment installation, performance, maintenance and testing. (NFPA 110 "Standard for Emergency and Standby Power Systems" Chapter 2 definitions [Ref. 10.6].)

**Level 1.** The most stringent equipment performance requirements for applications where failure of the equipment to perform could result in loss of human life or serious injuries. All Level 1 equipment shall be permanently installed. Level 1 includes E&SPS designated by LANL as ML1 and ML2. Level 1 also includes ML3 E&SPS that supply life safety systems. (NFPA 110 "Standard for Emergency and Standby Power Systems" Chapter 2 definitions [Ref. 10.6], and LIR 230-04-01 and LIG 230-01-02 [Ref. 10.9 and 10.10].)

**Level 2.** Equipment performance requirements for applications where failure of the E&SPS to perform is less critical to human life and safety and where it is expected that the authority having jurisdiction will exercise its option to allow a higher degree of flexibility than provided by Level 1. All Level 2 equipment shall be permanently installed. Level 2 includes less critical to human life E&SPS designated by LANL as ML-3. (NFPA 110 "Standard for Emergency and Standby Power Systems" Chapter 2 definitions [Ref. 10.2] and LIR 230-04-01 and LIG 230-01-02 [Ref. 10.9 and 10.10].)



**Type.** Type defines the maximum time, in seconds, that the E&SPS will permit the load terminals of the transfer switch to be without acceptable electrical power. *Table 3-2* provides the types defined by this standard.

**Table 3-2 Types of E&SPS**

Type	Time in Seconds
Type U	Basically uninterruptible (UPS system)
Type 10	10 seconds
Type 60	60 seconds
Type 120	120 seconds
Type M	Manual stationary or non-automatic - no time limit

## **4.0 RESPONSIBILITIES**

### **4.1 FWO-Systems, Engineering and Maintenance (SEM)**

#### **4.1.1** FWO-SEM is responsible for the technical content of this Criterion and monitoring the applicability and the implementation status of this Criteria and either assisting the organizations that are not applying or meeting the implementation expectations contained herein or elevating their concerns to the director(s).

*Basis:* LIR 301-00-01.11; Issuing and Managing Laboratory Operations Implementation Requirements and Guidance, Section 5.4, OIC Implementation Requirements.

#### **4.1.2** FWO-SEM shall provide technical assistance to support implementation of this Criterion.

### **4.2 Facility Manager**

#### **4.2.1** Responsible for operations and maintenance of institutional, or Real Property and Installed Equipment (RP&IE) under their jurisdiction, in accordance with the requirements of this document.

- 4.2.2** Responsible for operations and maintenance of those Personal Property and Programmatic Equipment (PP&PE) systems and equipment addressed by this document that may be assigned to the FM in accordance with the FMU-specific Facility/Tenant Agreement.

### **4.3 Group Leader**

- 4.3.1** Responsible for operations and maintenance of those Personal Property and Programmatic Equipment (PP&PE) systems and equipment addressed by this document that are under their jurisdiction

- 4.3.2** Responsible for system performance analysis and subsequent replacement or refurbishment of assigned PP&PE.

### **4.4 Authority Having Jurisdiction (AHJ) – Fire Marshal**

The AHJ is responsible for providing a decision on a specific technical question regarding this criterion.

## **5.0 PRECAUTIONS AND LIMITATIONS**

### **5.1 Precautions**

This section is not intended to identify all applicable precautions necessary for implementation of this Criterion. A compilation of all applicable precautions shall be contained in the implementing procedure(s) or work control authorization documents. The following precautions are intended only to assist the author of a procedure or work control document in the identification of hazards/precautions that may not be immediately obvious.

- 5.1.1** Only fully trained and qualified persons with proper test equipment and personal protective equipment shall be authorized to perform E&SPS maintenance. (LIR 402-600-01 [Ref. 10.8] Section 7.3.3; NFPA 70E [Ref.10.15] Part II Section 3-1 and Part III Section 2-1).
- 5.1.2** A specific lock-out/tag-out procedure should be developed for the maintenance of each E&SPS. E&SPS present a special lock-out/tag-out challenge due to the presence of multiple electrical power potentials available within a transfer switch.
- 5.1.3** Operating engines at no-load or loads less than 30% of the standby power rating for prolonged periods of time may result in:
- Wet Stacking - Wet stacking manifests itself in the accumulation of carbon particles, unburned fuel, lube oil, condensed water and acids in the exhaust system. This accumulation is due to incomplete combustion caused by low combustion temperatures.

- Carboning - Carboning is the result of carbon particles deposited on top of the piston rings and in the injectors due to incomplete burning of fuel.
- Fuel Dilution of Lube Oil - Piston rings are designed for optimum sealing under elevated combustion pressures. "When these pressures are not achieved due to the application of low loads, the fuel injected into the combustion chamber can get past the piston rings causing a fuel dilution situation in the lubricating oil.
- Water Contamination of Lube Oil - If the lubricating oil does not attain the desirable operating temperature, condensation of water may form in the engine oil pan.
- Piston Detonation - Piston detonation damage is caused by excessive engine idling or low load conditions that lead to localized burning of fuel above the top ring when larger loads are required of the engine.

(Cummins Application Engineering Bulletin AEB 10.17 [Ref. 10.16].)

**5.1.4** During maintenance and testing operations, personnel shall not stand directly in front of an automatic transfer switch when a transferring operation is taking place. (NFPA 110 [Ref. 10.6].)

**5.1.5** Assure all safety shields are properly installed and remain solidly in place for personnel protection, for example, fan belt, fan, generator to driver coupling, turbocharger and exhaust manifold blankets. (API 7C-11F [Ref. 10.20].)

**5.1.6** The following check list gives common causes of fires and explosions due to ignition of uncontrolled flow of gas and/or oil, and recommendations for minimizing their potential.

CAUSES	SUGGESTED PREVENTION
Lack of proper equipment for shutting down engines in an emergency.	Switches or other equipment should be provided for emergency stopping. Remote controls, and controls at the engine should be present and operable to provide immediate safe shutdowns.
Hot exhaust manifolds and piping.	Provide for water-cooled exhaust manifolds or proper covering for exhaust manifolds and piping with fireproof insulating material.
Flame from leaky exhaust manifold or piping.	Exhaust manifolds should have fireproof gaskets between bolted connections, or should be made from pipe with screwed or welded connections.
Sparks or fire from end of engine exhaust stack.	A spark-arrester type exhaust silencer should be installed.

CAUSES	SUGGESTED PREVENTION
Opening of engine cylinder cocks (where applicable).	Cylinder cocks of engines should not be opened when a flame or spark may be discharged from them into a gas-laden atmosphere.
Sparking from engine electrical systems.	The elements of an engine electrical system should never be manipulated so as to create a spark in gas-laden atmosphere.
Electrical Storage Batteries	Should be provided with suitable covers to prevent accidental contacting of battery terminals and consequent electrical arcing.
Electric Starters	Should be protected with a tight-fitting cover band, or cover band gasket to shield commutator arcing.

**5.1.7** Strict prohibition of open fires, lighted matches, and smoking should be insisted upon near internal-combustion engines. Combustible materials should also be kept at safe distances from hot surfaces of engines and their exhaust systems.

**5.1.8** At least two persons shall always be present when working on E&SPS. (DOE-STD-3003 Section 4.7 [Ref. 10.7].)

**5.1.9** Assure exhaust from generators are not being drawn into air intakes or open windows of buildings.

## 5.2 Limitations

The intent of this Criterion is to identify the minimum generic requirements and recommendations for SSC operation and maintenance across the Laboratory. Each user is responsible for the identification and implementation of additional facility specific requirements and recommendations based on their authorization basis and unique equipment and conditions, (e.g., equipment history, manufacturer warranties, operating environment, vendor O&M requirements and guidance, etc.).

Nuclear facilities and moderate to high hazard non-nuclear facilities will typically have additional facility-specific requirements beyond those presented in this Criterion. Nuclear facilities shall implement the requirements of DOE Order 4330.4B (Ref. 10.3) as the minimum programmatic requirements for a maintenance program. Additional requirements and recommendations for SSC operation and maintenance may be necessary to fully comply with the current DOE Order or CFR identified above.

## **6.0 REQUIREMENTS**

Minimum requirements that Criterion users shall follow are specified in this section. Requested variances to these requirements shall be prepared and submitted to FWO-SEM in accordance with LIR 301-00-02 (Ref. 10.4), "Variances and Exceptions to Laboratory Operations Requirements," for review and approval. The Criterion users are responsible for analysis of operational performance and SSC replacement or refurbishment based on this analysis. Laws, codes, contractual requirements, engineering judgment, safety matters, and operations and maintenance experience drive the requirements contained in this section.

### **6.1 Operations Requirements**

- 6.1.1** The routine maintenance and operational testing program shall be based on the manufacturer's recommendations, instruction manuals, and the minimum requirements of NFPA-110 Chapter 6, and the authority having jurisdiction (AHJ - FWO-FIRE).

*Basis:* NFPA 110 "Emergency and Standby Power Systems," Section 6-3 (Ref. 10.6). Compliance with NFPA Code is required as per Appendix G of the UC/DOE contract.

- 6.1.2** Emergency operating procedures shall be located where they are readily available to personnel operating or maintaining the engine.

*Basis:* NFPA 37 Standard for the Installation and Use of Internal Combustion Engines and Gas Turbines, Chapter 9 (Ref. 10.17). Compliance with NFPA Code is required as per Appendix G of the UC/DOE contract.

- 6.1.3** Personnel involved in the operations of engines shall be trained in the proper use of portable fire extinguishers.

*Basis:* NFPA 37 Standard for the Installation and Use of Internal Combustion Engines and Gas Turbines, Chapter 9 (Ref. 10.17). Compliance with NFPA Code is required as per Appendix G of the UC/DOE contract.

- 6.1.4** Any test that demonstrates equipment being tested does not meet a design requirement shall constitute a failure or reportable occurrence.

*Basis:* DOE-STD-3003-2000, Section 4.8 and DOE O 232.1A "Occurrence Reporting and Processing of Operations Information. DOE Order 232.1A is required as per Appendix G of the UC/DOE contract and Work Smart Standards. (Ref. 10.7 and 10.18)

**6.1.5** Level 1 E&SPS, including all appurtenant components, shall be inspected weekly.

*Basis:* NFPA 110 "Emergency and Standby Power Systems," Section 6-4 (Ref. 10.6). Compliance with NFPA Code is required as per Appendix G of the UC/DOE contract.

**6.1.6** Generator sets in Level 1 and Level 2 service shall be exercised at least once monthly, for a minimum of 30 minutes, using one of the following methods:

- Under operating temperature conditions or at not less than 30 percent of the E&SPS nameplate rating
- Loading that maintains the minimum exhaust temperatures as recommended by the manufacturer

*Note:* The date and time of day for required testing shall be decided by the owner, based on facility operations.

*Basis:* NFPA 110 "Emergency and Standby Power Systems," Section 6-4 (Ref. 10.6). Compliance with NFPA Code is required as per Appendix G of the UC/DOE contract.

**6.1.6.1** Equivalent loads used for testing shall be automatically replaced with the emergency loads in case of failure of the primary source.

*Basis:* NFPA 110 "Emergency and Standby Power Systems," Section 6-4 (Ref. 10.6). Compliance with NFPA Code is required as per Appendix G of the UC/DOE contract.

**6.1.6.2** Level 1 & 2 Diesel-powered E&SPS installations that do not meet the requirements of 6.1.6 shall be exercised monthly with the available E&SPS load and exercised annually with supplemental loads at 25 % of nameplate rating for 30 minutes, followed by 50% of nameplate rating for 30 minutes, followed by 75% nameplate rating for 60 minutes, for total of 2 continuous hours.

*Basis:* NFPA 110 "Emergency and Standby Power Systems," Section 6-4 (Ref. 10.6). Compliance with NFPA Code is required as per Appendix G of the UC/DOE contract.

**6.1.7** Load tests of generator sets shall include complete cold starts.

*Basis:* NFPA 110 "Emergency and Standby Power Systems," Section 6-4 (Ref. 10.6). Compliance with NFPA Code is required as per Appendix G of the UC/DOE contract.

- 6.1.8** All new and existing above-ground oil/fuel storage tanks including vaulted tanks greater than 660 gallons are required to have a Spill Prevention Control and Countermeasure (SPCC) plan developed and implemented prior to a tank being placed into operation.

*Basis:* LIR 404-50-01.0 "Water Pollution Control" Attachment 4

- 6.1.9** Time delays shall be set as follows:

- Time delay on start: 1 second minimum (*Exception: Gas turbine cycle: 0.5 second minimum*)
- Time delay on transfer to emergency: no minimum required
- Time delay on restoration to normal: 5 minutes minimum
- Time delay on shutdown: 5 minutes minimum
- Maximum time delay, in seconds, that the E&SPS may permit the load terminals of the transfer switch to be without acceptable electrical power is based upon the "Type" classification of the E&SPS. Refer to Definitions Section, Table 3-1 for details.

*Basis:* NFPA 110 "Emergency and Standby Power Systems," Section 6-4 (Ref. 10.6). Compliance with NFPA Code is required as per Appendix G of the UC/DOE contract.

- 6.1.10** Level 1 and Level 2 transfer switches shall be operated monthly. The monthly test of a transfer switch shall consist of electrically operating the transfer switch from the standard to the alternate position and then a return to the standard position.

*Basis:* NFPA 110 "Emergency and Standby Power Systems," Section 6-4 (Ref. 10.6). Compliance with NFPA Code is required as per Appendix G of the UC/DOE contract.

- 6.1.11** The routine operational testing program shall be overseen by a properly instructed individual.

*Basis:* NFPA 110 "Emergency and Standby Power Systems," Section 6-4 (Ref. 10.6). Compliance with NFPA Code is required as per Appendix G of the UC/DOE contract.

- 6.1.12** E&SPS circuit breakers for Level 1 system usage, including main and feed breakers between the emergency power generator and the transfer switch load terminals, shall be exercised annually with the emergency power generator in the off position.

*Basis:* NFPA 110 "Emergency and Standby Power Systems," Section 6-4 (Ref. 10.6). Compliance with NFPA Code is required as per Appendix G of the UC/DOE contract.

## **6.2 Maintenance Requirements**

**6.2.1** The routine maintenance and operational testing program shall be based on the manufacturer's recommendations, instruction manuals, and the minimum requirements of NFPA-110 Chapter 6, and the authority having jurisdiction (AHJ - FWO-FIRE).

*Basis:* NFPA 110 "Emergency and Standby Power Systems," Section 6-3 (Ref. 10.6). Compliance with NFPA Code is required as per Appendix G of the UC/DOE contract.

**6.2.2** Hour meters shall be installed and maintained on all operating, stationary electrical generator systems. The hour meters shall be checked for functionality every 6 months.

*Basis:* New Mexico Administrative Code, 20 NMAC 2.72.202B. (3) - Air Quality Construction Permitting requires verification that stationary emergency generators are exempt from air quality permitting if:

- (a) they are operated only during unavoidable loss of power and inspection and testing
- (b) they are operated less than 500 hours
- (c) they are accompanied by sufficient record keeping to verify that the generators are operated less than 500 hours (Hour Meters required [Ref. 10.19] ).

**6.2.3** Required maintenance activities and frequencies for Level 1 and Level 2 E&SPS are outlined in the table that follows. Further details of required maintenance activities could be found in Sections 6.3 and 6.4 of NFPA 110 and API 7C-11F Section 6. Refer to manufacturers and designer specifications for maintenance testing acceptance criteria.

*Basis:* NFPA 110 "Emergency and Standby Power Systems," Section A-6-3.1 (Ref. 10.6) and API Recommended Practice 7C-11F Fifth Edition, November 1, 1994, Section 6 (Ref. 10.20). Compliance with NFPA 110 and API 7C-11F are required as per Appendix G of the UC/DOE contract and Work Smart Standards.



Table 6-1 Maintenance Requirements

Component (as applicable)	Procedure X – Action R--Replace, if needed					Frequency	
	Visual Inspection	Check	Change	Clean	Test	W-Weekly M--Monthly Q--Quarterly	S--Semiquarterly A--Annually #s indicate hours
						Level 1 ML1, ML2, ML3 (life safety)	Level 2 ML3
<b>1. Fuel System</b>							
(a) Main supply tank level		X				W	M
(b) Day tank level	X	X				W	M
(c) Day tank float switch	X				X	W	Q
(d) Supply or xsfr pump ops	X				X	W	Q
(e) Solenoid valve ops	X				X	W	Q
(f) Strainer, filter, dirt leg or combo.				X		Q	Q
(g) Water in system		X		X		W	Q
(h) Flex hose and connectors	X		R			W	M
(i) Tank vents & overflow piping unobstructed		X			X	A	A
(j) Piping	X					A	A
(k) Gasoline in main tank (when used)			R			A	A
<b>2. Lubricating System</b>							
(a) Oil level	X	X				W	M
(b) Oil change			R			50 or A	50 or A
(c) Oil filter(s)			X			50 or A	50 or A
(d) Lube oil heater		X				W	M
(e) Crankcase breather	X		R	X		Q	S
<b>3. Cooling System</b>							
(a) Level	X	X				W	M
(b) Antifreeze protection level					X	S	A
(c) Antifreeze			X			A	A
(d) Adequate cooling water to heat exchanger		X				W	M
(e) Rod out heat exchanger				X		A	A
(f) Adequate fresh air through radiator		X				W	M
(g) Clean exterior of radiator				X		A	A
(h) Fan and alternator belt	X	X				M	Q
(i) Water pump(s)	X					W	Q
(j) Condition of flexible hoses and connections	X	X				W	M
(k) Jacket water heater		X				W	M
(l) Inspect duct work, clean louvers	X	X	X			A	A
(m) Louver motors and controls	X			X	X	A	A
<b>4. Exhaust System</b>							
(a) Leakage	X	X				W	M
(b) Drain condensate trap		X				W	M
(c) Insulation & fire hazards	X					Q	Q
(d) Excessive backpressure					X	A	A
(e) Exhaust system hangers	X					A	A

## Criterion 506: Emergency and Standby Power Systems

Date: 10/07/02

Revision 1

Table 6-1 Maintenance Requirements

Component (as applicable)	Procedure X – Action R--Replace, if needed					Frequency  W-Weekly M--Monthly Q--Quarterly  S--Semiquarterly A--Annually #’s indicate hours	
	Visual Inspection	Check	Change	Clean	Test	Level 1 ML1, ML2, ML3 (life safety)	Level 2 ML3
& supports							
(f) Flexible exhaust section	X					S	S
<b>5. Battery System</b>	Refer to O&M Criterion 511 for Battery Detail						
(a) Electrolyte level		X				W	M
(b) Terminals clean and tight	X	X				A	A
(c) Remove corrosion, case exterior clean and dry	X			X		M	M
(d) Specific gravity or state of charge					X	M	M
(e) Charger and charge rate	X					M	M
(f) Equalize charge		X				M	M
<b>6. Electrical System</b>							
(a) General inspection	X					W	M
(b) Tighten control & power wiring connections		X				A	A
(c) Wire chafing where subject to movement	X	X				Q	S
(d) Operation of safeties & alarms		X			X	S	S
(e) Boxes, panels, and cabinets				X		S	S
(f) Circuit breakers, fuses Note: Do not break mfgs seals or perform internal inspection on these devices	X	X	R	X	X	2 Hrs. or M	2 Hrs. or A
(g) Transfer switch main contacts	X			X		A	A
(h) Calibrate of voltage-sensing relays/devices		X			X	5 Hrs. or A	5 Hrs. or A
(i) Wire insulation breakdown					X	3 yrs. Or 500 Hrs.	5 yrs. Or 500 Hrs.
<b>7. Prime Mover</b>							
(a) General Inspection	X					W	M
(b) Service air cleaner			X	X		S	S
(c) Governor oil level and linkage	X	X				M	M
(d) Governor oil			X			A	A
(e) Ignition system -- plugs, points, coil, cap, rotor, secondary wire insulation	X	X	R	X	X	A	A
(f) Choke setting and carburetor adjustment		X				S	S
(g) Injector pump and injectors for flow rate pressure, and /or spray pattern					X	A	A
(h) E&SPS @ min. of 80% nameplate rating					X	Every 3 Yrs. For 4 hrs	Every 3 Yrs. For 4 hrs
(i) Valve clearance					X	Every 3 Yrs. Or 500 hrs	Every 3 Yrs. Or 500 hrs.
(j) Torque bolts					X	Every 3 Yrs. Or 500 hrs	Every 3 Yrs. Or 500 hrs.

Table 6-1 Maintenance Requirements							
Component (as applicable)	Procedure X – Action R--Replace, if needed					Frequency  W-Weekly M--Monthly Q--Quarterly  S--Semiquarterly A--Annually #’s indicate hours	
	Visual Inspection	Check	Change	Clean	Test	Level 1 ML1, ML2, ML3 (life safety)	Level 2 ML3
<b>8. Generator</b>							
(a) General inspection	X					W	M
(b) Brush Length, appearance, free to move in holder	X	X		X		S	S
(c) Commutator and slip rings	X			X		A	A
(d) Rotor and stator	X			X		A	A
(e) Bearing(s)	X		R			A	A
(f) Bearing grease		X	R			A	A
(g) Exciter	X	X		X		A	A
(h) Voltage regulator	X	X		X		A	A
(i) Measure and record resistance readings of windings with insulation tester (Megger)					X	A	A
<b>8. General E&amp;SPS</b>							
(a) General inspection for unusual conditions of vibration, leakage, noise, temperature, or deterioration	X			X		W	M
(b) Service room or housing housekeeping	X			X		W	M
(c) Restore system to automatic operation condition	X					W	M

*Basis:* NFPA 110 "Emergency and Standby Power Systems," Appendix A-6-3.1 (Ref. 10.6). Compliance with NFPA Code is required as per Appendix G of the UC/DOE contract.

**6.2.4** Additional required maintenance activities and frequencies for all stationary E&SPS internal combustion engines are outlined in the table that follows. Further details of these required maintenance activities can be found in Section 6 of API 7C-11F "Recommended Practice for Installation, Maintenance, and Operation of Internal-Combustion Engines." Assure awareness to manufacture's recommendations are kept under consideration.

**Note:** The maintenance frequency periods identified in the following table has been increased to fall in sequence with NFPA-110 frequencies. The API (American Petroleum Institute) frequencies are based upon constant running internal combustion engines, whereas the frequencies in NFPA-110 are based upon infrequent emergency operations and monthly test runs.

*Basis:* API Recommended Practice 7C-11F Fifth Edition, November 1, 1994, Section 6 (Ref. 10.20). Compliance with NFPA 110 and API 7C-11F are required as per Appendix G of the UC/DOE contract and Work Smart Standards.

**Table 6-2 Additional Internal Combustion Engine Requirements**

Engine Component	Requirement	Frequency
Turbocharger	Listen to sounds of turbocharger and note any variation from normal. Note intake manifold pressure and record same.	Monthly
Throttle and Governor	Governor linkage and butterfly-shaft-end shall be checked for free movement through their full range. Minor governor adjustments should be made, if needed; and throttle and governor controls shall be lubricated	Monthly
Air Box Drains	Air Box Drains shall be checked for proper functioning	Monthly
Gas Regulators (Nat. gas)	Gas engines shall be checked for gas pressure at the primary and final regulators.	Annual
Starting Equipment	Starting equipment shall be carefully tested and inspected. Check for proper lubrication and general condition; mounting bolts, bendix-drive lubrication, engagement linkage, pinion-gear mesh and adjustment. For air start systems; add recommended lubricant to air start reservoirs and clean air traps of dirt.	Annual

Engine Component	Requirement	Frequency
	Observe manufacture recommendations.	
Vibration Damper	Inspect vibration damper off crankshaft for damage, run-out, signs of deterioration or loss of viscous material, or looseness.	Annual
Turbocharger Impeller	Inspect turbocharger compressor impeller for accumulations of dirt, dust, and oil. Clean according to manufacturer's recommendations.	Annual
Exhaust manifolds, covers, valves, other devices	Inspect for protection against water entrance to exhaust manifolds, covers, valves, or other devices should be checked	Annual
Turbo-Intercooler	Check drive, bearings, seals, and coolant flow of intercooler water pump. Clean intercoolers according to manufacturer's instructions.	Annual
Engine Mounts	Engine mounts shall be inspected and tightened, if require, to manufacture's specifications. The inspection shall also include signs of engine shifting, misalignment, loosening of coupling or pulley, or improper loading. Any shifting shall be corrected and all points of alignment rechecked.	3 yrs. or every 500 hrs.

*Basis:* API Recommended Practice 7C-11F Fifth Edition, November 1, 1994, Section 6 (Ref. 10.20). Compliance with API 7C-11F is required as per Appendix G of the UC/DOE contract and Work Smart Standards.

**6.2.5** Immediately following Maintenance required activities perform post maintenance test as follows: operating and run testing guidance can be utilized as follows:

1. Perform maintenance as per Table 6-1, 6-2 in Requirements Section	8. Record initial oil pressure and battery charging rate.
2. Record running time meter reading at start and end of test.	9. Record oil pressure, battery -charging rate, and water or air temperature after 15 minutes run time.
3. Simulate normal power failure from a "cold start" by use of the test switch in the automatic transfer switch or by opening normal power supply to E&SPS	10. Return test switch to normal or re-establish normal power supply at such time to cause a minimum running time of 30 minutes under load.
4. Observe and record time delay on start.	11. Record prime mover and ac instruments just prior to transfer.
5. Record cranking time (terminates when engine starts).	12. Record time delay on re-transfer.
6. Transfer load	13. Record time delay on shutdown for units so equipped.
7. Record AC voltage, Frequency, and Amperage	14. Place unit in automatic operation mode.

*Basis:* New Mexico Administrative Code, 20 NMAC 2.72.202B. (3) - Air Quality Construction Permitting requires verification that stationary emergency generators are exempt from air quality permitting if:

- (d) they are operated only during unavoidable loss of power and inspection and testing
- (e) they are operated less than 500 hours
- (f) they are accompanied by sufficient record keeping to verify that the generators are operated less than 500 hours (Hour Meters required [Ref. 10.19] ).

## 7.0 RECOMMENDATIONS AND GOOD PRACTICES

The information provided in this Section is recommended based on acceptable industry practices and should be implemented by each user based on his/her unique application and operating history of the subject systems/equipment.

## **7.1 Operations Recommendations**

- 7.1.1** E&SPSs are recommended to be exercised with a minimum 30% load of nameplate or the manufacturers recommended exhaust stack temperature for a minimum 30 minutes. Generators are often exercised at a No-Load for 30 minutes, or until the engine has reached stabilized coolant temperatures. Repeated, extended operating (> 30 minutes) without load can cause combustion -related problems that may lead to engine damage. Utilizing load banks are recommended when possible to provide proper engine temperatures.

*Basis:* Cummins Application Engineering Bulletin AEB 10.17 (Ref. 10.16)

- 7.1.2** Life-limited components - Sufficient quantities of spares should be maintained and should be replaced according to manufacturers directions.

*Basis:* IEEE 446 Emergency and Standby Power Systems for Industrial and Commercial Applications, Chapter 8 (Ref. 10.11).

- 7.1.3** Fuel system operations and design should consider the safe provision of an adequate supply of clean, fresh, fuel to the prime mover. Untreated diesel has an approximate storage life of 1.5 to 2 years and untreated gasoline has a storage life of approximately 6 months. Treated fuels may have larger storage periods. Provisions should be made to operate in such a way that fuel will be replenished within storage life periods and/or stale fuels will be replaced with fresh fuels.

*Basis:* NFPA 110 "Standard for Emergency and Standby Power Systems", Section Appendix A, A-5-9.1. (Ref. 10.6).

- 7.1.4** Personnel who operate and/or maintain E&SPS should have the following:

- An understanding of NFPA-101 "Life Safety Code" and manufacturers test procedures and frequencies
- Special training at manufacturers location for equipment starting, shutdowns and routine maintenance
- A complete set of step-by-step test and maintenance procedures
- Physical access to E&SPS equipment to perform tests within required frequencies
- Management support to perform tests within required frequencies

*Basis:* Reference IEEE 446 Emergency and Standby Power Systems for Industrial and Commercial Applications, Chapter 8 (Ref. 10.11).

- 7.1.5** Whenever additional loads are connected to an E&SPS, check the protective device coordination, calibration, and proper operation of the modified system

*Basis:* NFPA 70B Section 22-2.2.8 (Ref. 10.12)

## 7.2 Maintenance Recommendations

**7.2.1** Maintenance intervals for recommended operational inspection and testing should take into consideration the type of service to which the E&SPS is subjected (duty cycle, chemicals, dust, heat), age and condition of the equipment, manufacturer's recommendations, and trending. Table 7-1 should be utilized in conjunction with Table 3-1 and 3-2 for E&SPS to enhance the maintenance frequencies based upon the different conditions of the E&SPS equipment.

**Table 7-1 Maintenance Frequency Multiplier Chart**

Maintenance Frequency Multiplier Chart				
		Equipment Condition or Operating Environment		
		POOR	AVERAGE	GOOD
Equipment Reliability Requirement	LOW (ML4)	1.00	2.00	2.50
	MEDIUM (Level 2, ML3 )	0.50	1.00	1.50
	HIGH (Level 1, ML1&ML2)	0.25	0.50	0.75

*Basis:* NFPA 70B "Recommended Practice for Electrical Equipment Maintenance" Appendix H, Maintenance Guidelines and NETA MTS-2001 Appendix B "Frequency of Maintenance Tests" (Ref. 10.12 and 10.13).

**Sample usage of Table 7-1:** Select a particular required maintenance activity from Table 3-1 or 3-2. Suppose the frequency of the activity is monthly. Now determine the condition of a specific E&SPS. Is it in poor, average, or good condition or operating environment? Selecting the condition of the equipment is based upon age, hot, dirty, corrosive environment, or simply a problematic piece of equipment. It could be new with very few hours of service. Let's say we selected an operating condition of "Good" (above average). After selecting the equipment condition, select the management level requirement. Let's say we selected ML3. Selecting the two criteria on Table 7-1 provides us with a multiplier of 1.5. The frequency of the particular maintenance activity selected now has become increased from monthly to every 6 weeks.



## **8.0 GUIDANCE**

### **8.1 Operations Guidance**

- 8.1.1** The applicable training courses for portable fire extinguisher usage is provided by ESH-13. The course numbers are 15672, "Designated Worker and Fire Watch" (Annual Self-Study), and 9893, "Fire Extinguisher Hands-on Training."
- 8.1.2** Utilize LIR 402-130-01.1 "Abnormal Events" for directives on proper Occurrence Reporting at LANL. (Ref. 10.20)
- 8.1.3** ESH 18 will provide information, guidance and/or provide actual Spill Prevention Control and Countermeasure (SPCC) plans, if requested, for those who may need assistance in development or implementation of a proper SPCC.
- 8.1.4** During monthly testing of E&SPS, transfer switch operations can be operated and verified in sequence with the engine/generator run test. Certain specific E&SPS may require backup generation to individual loads to allow for this testing to occur, to assure there is no interruption of critical loads.
- 8.1.5** A properly instructed or trained individual responsible for the overseeing of a routine operational testing program may be someone with the following:
- A qualified individual shall be trained and knowledgeable of the construction and operation of the E&SPS. He would be trained and experienced to recognize and avoid the electrical and mechanical hazards that might be present with respect to the E&SPS equipment. The individual shall also be familiar with the proper use of special precautionary techniques, personal protective equipment, insulating and shielding material, and insulated tools and test equipment. Ref. 10.12.

### **8.2 Maintenance Guidance**

- 8.2.1** ESH-16 performs record keeping on all known stationary E&SPS for total run hours to meet NMAC 2.72.202B. (Ref. 10.19)
- 8.2.2** Special tools and testing devices required to perform proper maintenance should be kept in a secure and available location for technicians to perform their tasks correctly. Utilizing the table in section 6.2.3, a written schedule, or schedule entered into a computerized maintenance management system (CMMS) would be very effective.
- 8.2.3** Provided it has been reviewed and approved by FWO-SEM, an acceptable preventive maintenance inspection and testing program for E&SPS may be found in the JCNNM preventive maintenance instruction PMI 40-25-007, "Backup Generator Systems Maintenance, Repair and Testing."

- 8.2.4** Manage the maintenance and cleanliness of an E&SPS engine (driver) to a like-new condition at all times. Dirt and corrosion are major causes of equipment failures. Reference IEEE 446 Emergency and Standby Power Systems for Industrial and Commercial Applications, Chapter 8. (Ref. 10.6)
- 8.2.5** The best method recommended for cleaning of generator windings is a vacuum cleaner with proper fittings. Compressed air is not recommended, it normally just re-deposits dust and contaminants to another location. Reference IEEE 446 Emergency and Standby Power Systems for Industrial and Commercial Applications, Chapter 8. (Ref. 10.6)

A review of DOE Occurrence Reports from FY 1995 through FY 2001 that were filtered for "electrical equipment" then for "emergency generators" yielded 210 occurrence reports. This criterion encompasses most of the operations and maintenance-related occurrences identified in Table 8-1. These reports are categorized and ranked in the following order:

**Table 8-1 DOE Facilities Occurrences**

<b>Failure Type</b>	<b># Failures</b>	<b>% of Total Failures</b>
Cooling Systems	42	20.00%
Electrical Components	28	13.33%
Poor Procedures	24	11.43%
Battery system failures	20	9.52%
Unknown occurrences	19	9.05%
Design Problems	14	6.67%
Insufficient Training	13	6.19%
Fuel Problems	9	4.29%
Air System Problems	6	2.86%
Governor Problems	6	2.86%
Maintenance Frequencies	6	2.86%
Old Obsolete Equipment	6	2.86%
Generator Failures	5	2.38%
Mechanical Failures	4	1.90%
Safety System Actuations	3	1.43%
Instrumentation failures	3	1.43%
External Electrical Faults	2	0.95%

## 9.0 REQUIRED DOCUMENTATION

Maintenance history shall be maintained for E&SPS to include, as a minimum, the parameters listed in the Table 9-1 below:

**Table 9-1 Documentation Parameters**

<b>MAINTENANCE HISTORY DOCUMENTATION PARAMETERS</b>				
<b>PARAMETER</b>	<b>ML1</b>	<b>ML2</b>	<b>ML3 affecting life safety</b>	<b>ML3 NOT affecting life safety</b>
<b>Maintenance Activities</b>				
Maintenance Date	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
PM Activities Performed	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
Parts Replaced	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
Modifications Made	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
Post Maintenance Testing Performed	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
Identification of Maintenance Personnel	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
<b>Equipment Problems</b>				
Failure Dates	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
Failure Root Cause	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
Corrective Actions Taken	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
Parts Replaced	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
Post-Repair Testing Performed	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
Date Returned to Service	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
Identification of Servicing Personnel	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
<b>Inspection Results</b>				
Inspection Date	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
Inspection Performed	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
Start Reliability (IEEE Std 762 def.)	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
Tests Performed	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
E&SPS Condition	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
Meter Readings	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
Identification of Inspecting Personnel	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>

*Basis:* Documentation of the parameters listed in Table on the previous page satisfies the requirements of LPR 230-07-00, Criteria 2, (Ref. 10.14)

which states; "Maintenance activities, equipment problems, and inspection and test results are documented." NFPA 110 (Ref. 10.6), Section 6, and DOE Std 3003 (Ref. 10.7) require References.

## **9.1 Additional Documentation**

- 9.1.1** For Level 1 systems, one set of instruction manuals shall be kept in a secure, convenient location near the equipment. The other set shall be kept in a different secure location.

*Basis:* NFPA 110 "Emergency and Standby Power Systems," Section 6-4 (Ref. 10.6)

## **10.0 REFERENCES**

The following references, and associated revisions, were used in the development of this document.

- 10.1** LIR 230-05-01.0, Operation and Maintenance Manual.
- 10.2** DOE O 430.1A, Attachment 2 "Contractor Requirements Document" (Paragraph 2, Sections A through C), a requirement of Appendix G of the UC Contract.
- 10.3** DOE Order 4330.4B, Maintenance Management Program, Section 3.4.9.
- 10.4** LIR 301-00-02.0, Variances and Exceptions to Laboratory Operation Requirements.
- 10.5** LPR 230-07-00, Maintenance History, Performance Criteria [2].
- 10.6** NFPA 110 Standard for Emergency and Standby Power Systems.
- 10.7** DOE-STD-3003-2000, DOE Standard Backup Power Sources for DOE Facilities.
- 10.8** LIR 402-600-01.1, Electrical Safety.
- 10.9** LIR 230-04-01.1, Laboratory Maintenance Management Program.
- 10.10** LIG 230-01-02.0, Graded Approach for Facility Work.
- 10.11** IEEE Std 446, Emergency and Standby Power Systems for Industrial and Commercial Applications.
- 10.12** NFPA 70B, Recommended Practice for Electrical Equipment Maintenance.
- 10.13** NETA MTS-2001 Appendix B "Frequency of Maintenance Tests."
- 10.14** LPR 230-07-00, Maintenance History.
- 10.15** NFPA 70E, Standard for Electrical Safety Requirements for Employee Workplaces.
- 10.16** Cummins Application Engineering Bulletin AEB 10.17.
- 10.17** NFPA 37, Standard for the Installation and Use of Internal Combustion Engines and Gas Turbines.

**10.18** DOE O 232.1A, Occurrence Reporting and Processing of Operations Information.

**10.19** New Mexico Administrative Code, 20 NMAC 2.72.202B. (3) - Air Quality Construction Permitting.

**10.20** LIR 402-130-01.1, Abnormal Events

**10.21** API Recommended Practice 7C-11F 5<sup>th</sup> Edition "Recommended Practice for Installation, Maintenance, and Operation of Internal-Combustion Engines."

## **11.0 APPENDICES**

None